Stream Characteristics and Other Considerations for Macroinvertebrate Bioassessment of Puerto Rico Streams

- James Kurtenbach/USEPA Region 2

Outline

- Bioassessment background
- Natural factors (chemistry, habitat, and landscape)
- Anthropogenic factors
- Information gaps (invertebrate taxonomy, FFG's, pollution tolerance, and marine-freshwater link)
- Future bioassessment in Puerto Rico and Caribbean


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CARIBBEAN
worldatlas
Gulf of Mexico
Florida (U.S.)
Miami
Key West
Bahamas
Bermuda
70° W
60° W
25°N
TROPIC OF CANCER
Atlantic Ocean
Isla Mujeres
Cancun
Cozumel
Mexico
Cuba
Isle of Youth (Cuba)
Turks & Caicos (U.K.)
Caribbean Sea
Greater Antilles
HISPANIOLA
Haiti
Dominican Rep.
Cayman Islands (U.K.)
Jamaica
Virgin Islands (U.K.)
Puerto Rico (U.S.)
Saba (Neth.)
Anguilla (U.K.)
St. Martin/Sint Maarten
St. Barts (France)
Antigua and Barbuda
Virgin Islands (U.S.)
St. Eustatius (Neth.)
Guadeloupe (France)
St. Kitts and Nevis
Montserrat (U.K.)
Dominica
20°N
15°N
Turneffe Islands (Belize)
Islas de la Bahia (Hon.)
Belize
Honduras
Isla de Providencia (Col.)
300 mi
300 km
Caribbean Sea
Lesser Antilles
Martinique (France)
St. Lucia
CENTRAL AMERICA
Netherlands Antilles
Aruba
Bonaire
Curacao
Isla Los Roques (Ven.)
St. Vincent and the Grenadines
Barbados
Grenada
Isla de San Andres (Col.)
Nicaragua
Trinidad and Tobago
80° W
Costa Rica
Venezuela
10°N
Isla La Tortuga (Ven.)
Isla de Margarita (Ven.)
Pacific Ocean
PANAMA CANAL
Panama
Colombia
SOUTH AMERICA
Atlantic Ocean
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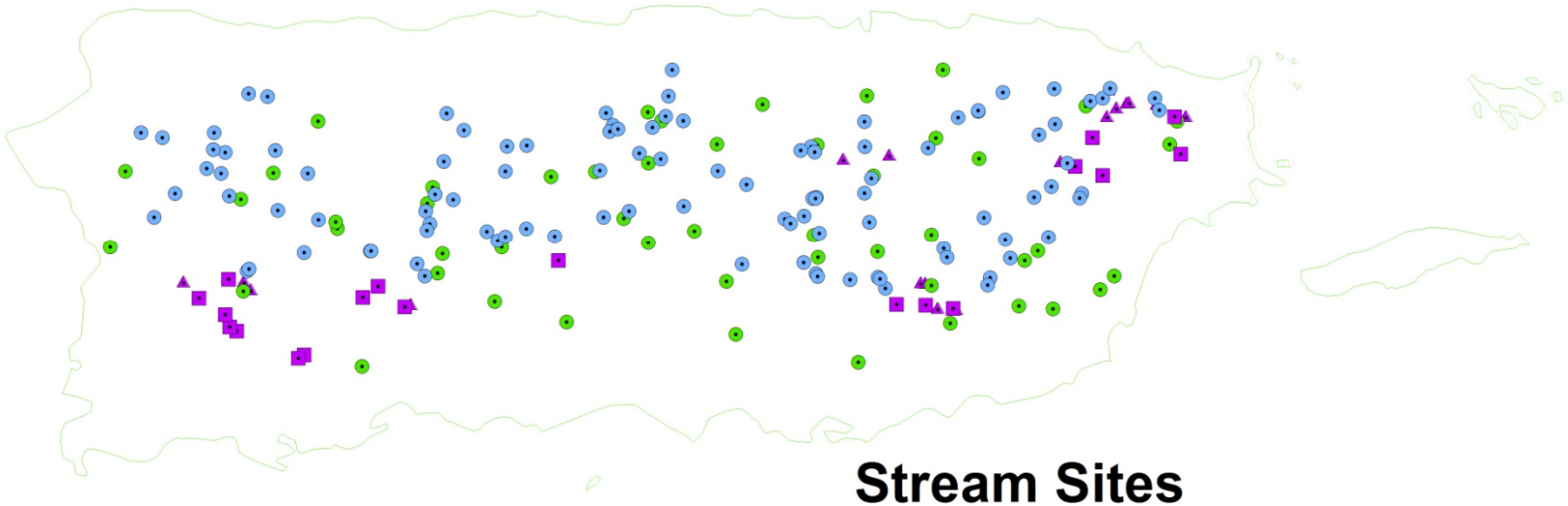
1994, 2006, 2009, 2011
Puerto Rico Biological Stream Survey's



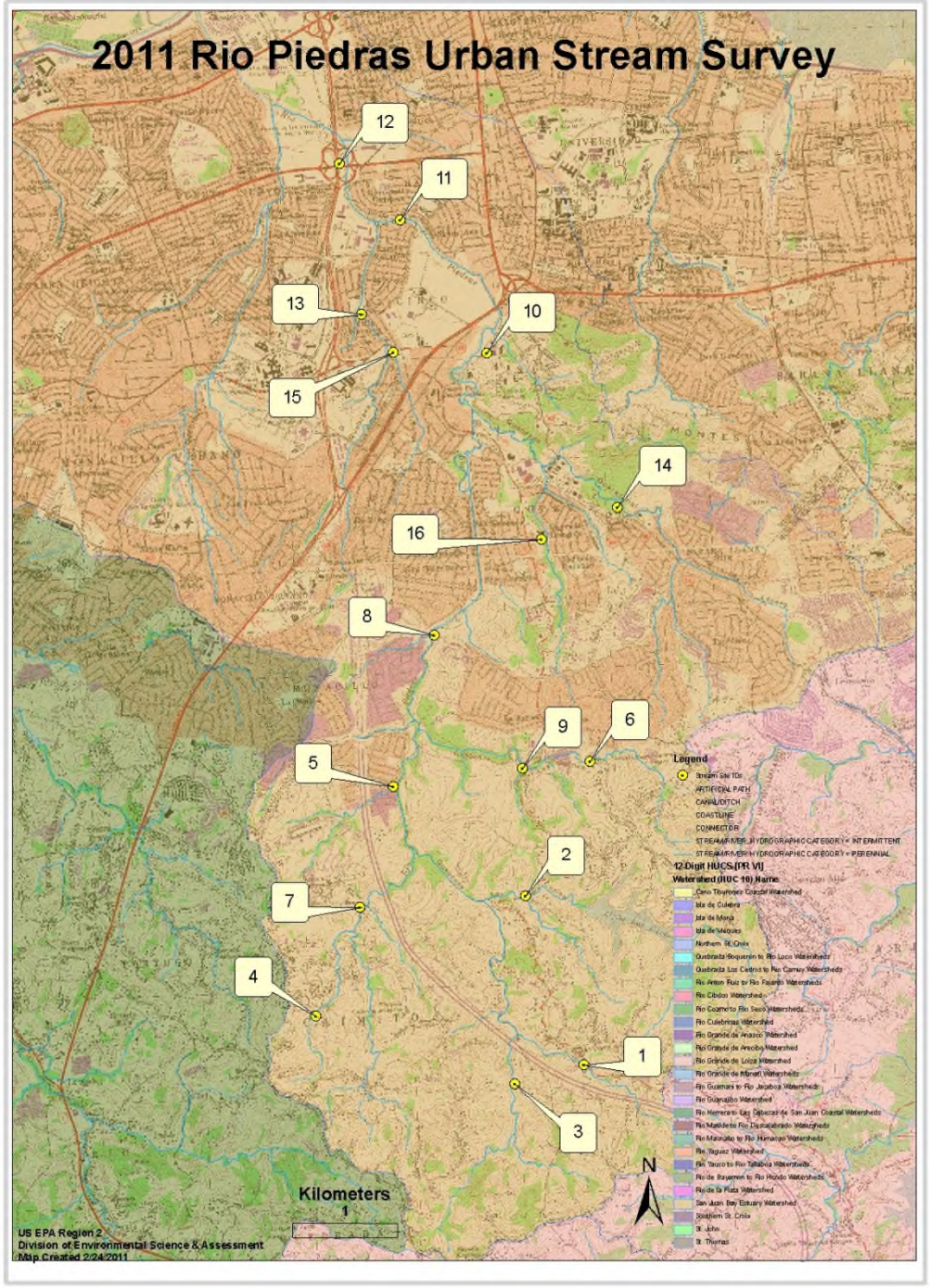
Stream Sites

- 1994 Targeted n = 105
- 2006 Probabilistic Reference n = 19
- 2009 Probabilistic n = 50
- 2011 Probabilistic Reference n = 20

EPA

N

Kilometers
50


2011 Rio Piedras Urban Stream Survey
12
11
13
10
15
14
16
8
9
6
5
2
7
4
1
3
Legend
Stream Sites
ARTIFICIAL PATH
CANAL/DITCH
COASTLINE
CONNECTOR
STREAM/RIVER HYDROGRAPHIC CATEGORY = INTERMITTENT
STREAM/RIVER HYDROGRAPHIC CATEGORY = PERENNIAL
12 Digit HUCS (PR VI)
Watershed (HUC 10) Name
Cano Tiburones Coastal Watershed
Isla de Culebra
Isla de Mona
Isla de Vieques
Northern St. Croix
Quebrada Boquerón to Río Loco Watersheds
Quebrada Las Cadenas to Río Camuy Watersheds
Río Anton Ruiz to Río Fajardo Watersheds
Río Cibuco Watershed
Río Cozmo to Río Saco Watersheds
Río Culebrinas Watershed
Río Grande de Arecibo Watershed
Río Grande de Arecibo Watershed
Río Grande de Loíza Watershed
Río Grande de Manatí Watersheds
Río Guamani to Río Jacaboa Watersheds
Río Guayanilla Watershed
Río Herrera to Las Cabezas de San Juan Coastal Watersheds
Río Matildes to Río Descalabrado Watersheds
Río Matrullo to Río Humacao Watersheds
Río Yaguez Watershed
Río Yauco to Río Tallaboa Watersheds
Río de Bayamón to Río Hondo Watersheds
Río de la Plata Watershed
San Juan Bay Estuary Watershed
Southern St. Croix
St. John
St. Thomas
Kilometers
1
N
US EPA Region 2
Division of Environmental Science & Assessment
Map Created 2/24/2011

Macroinvertebrate Field Collection

- Target riffle habitat
- Traveling kick net samples
- 5 minute duration and 5 meter distance
- March-April index period
- Specimens preserved with 10% formalin

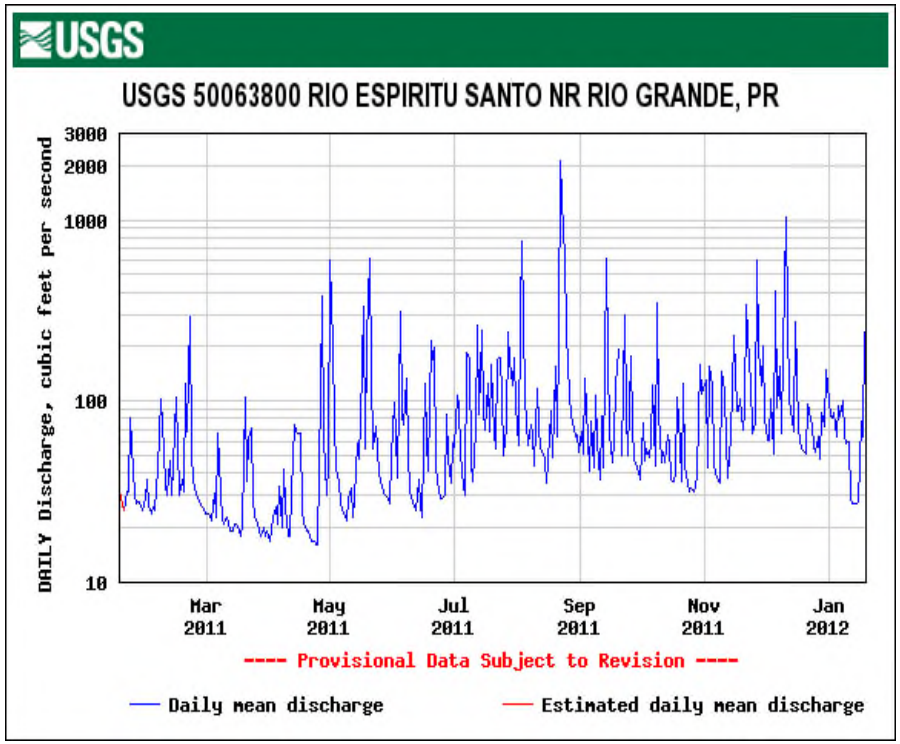
Lab Processing and Data Analysis

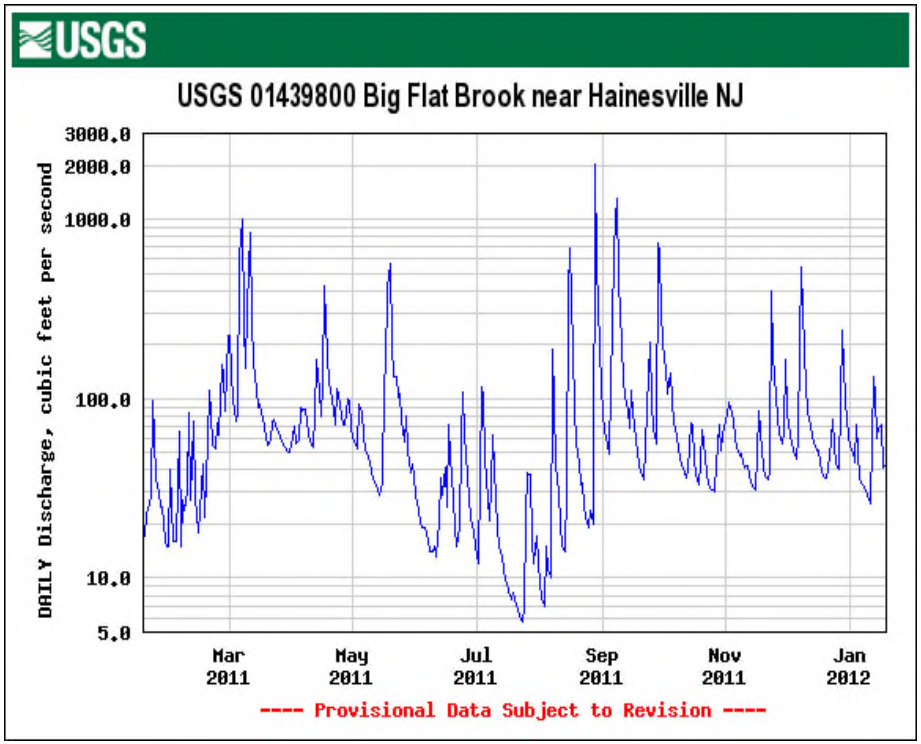
- 100 organism sub-count for lab ID's
- Family/genus level ID's
- Record ID's and counts on lab bench sheets
- Reference collection
- Calculate MII scores (0 – 100)

Landscape: Steep Topography

- 40% mountain (some peaks 1000 m) and 35% foothill
- Streams of short distance from headwaters to ocean
- High annual rainfall (some areas over 5000 mm)
- Elevation and implications for bioassessment

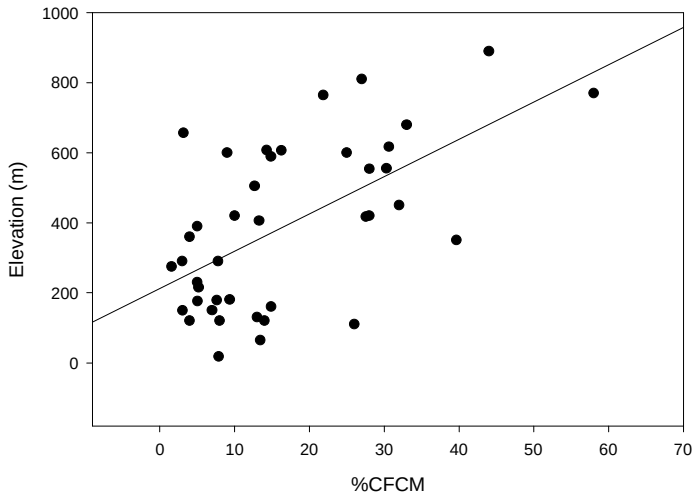
Water Discharge for a Puerto Rico and Temperate N.A. Stream



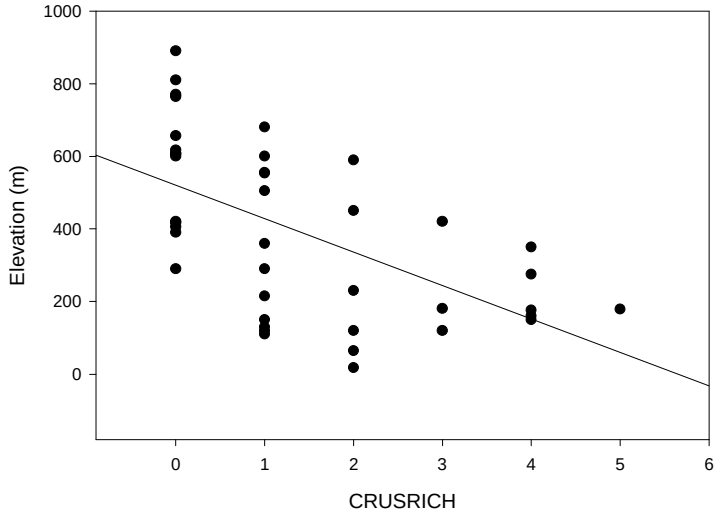


Elevation vs. Metrics

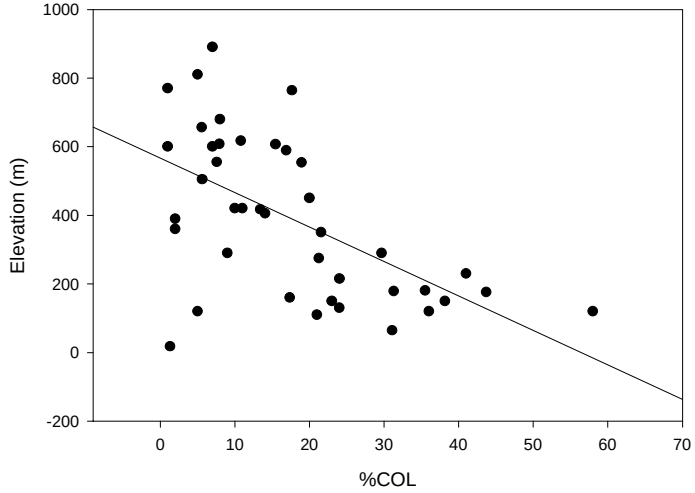
Elevation vs. PRCNTCFCM (r = 0.509, p= 0.000734)



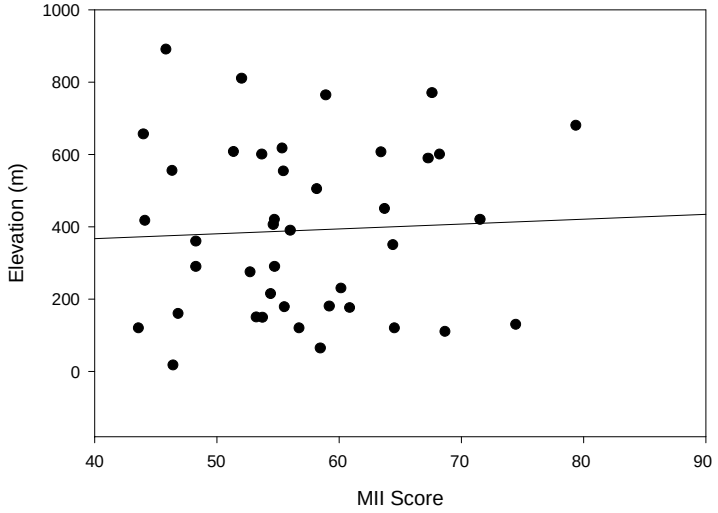
Elevation vs. CRUSRICH (r = -0.621, p = 0.0000154)



Elevation vs. PRCNTCOL (r = -0.557, 0.000172)



Elevation vs. MII Score (r = -0.00488, p= 0.975)

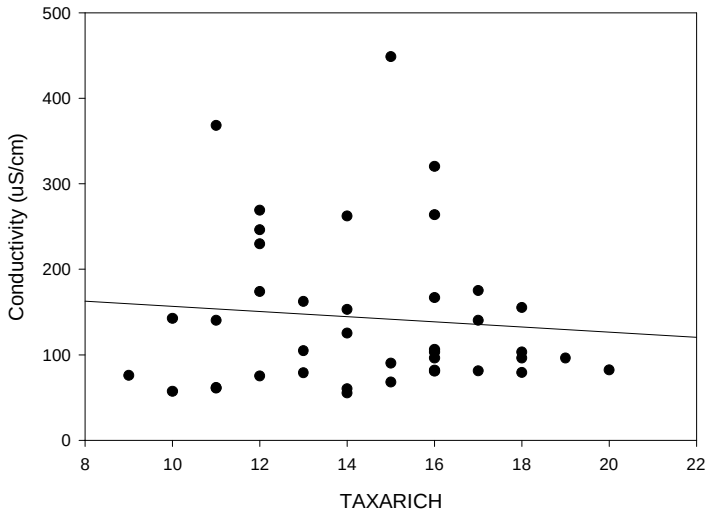


Water Chemistry and Geology

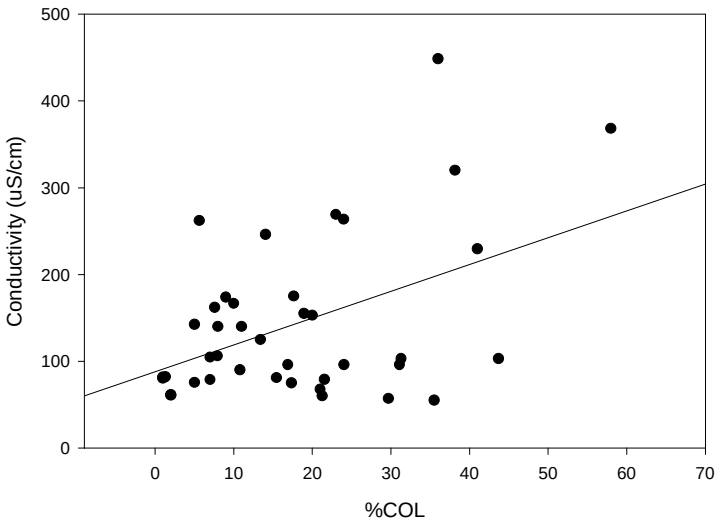
- Conductivity used as a surrogate for geology
- Puerto Rico is geologically complex
- Volcanic substrates of the Central and Luquillo Mountains
- Foothills comprised of marl, dolomite and calcareous sandstones
- Geological implications for bioassessment

Conductivity vs. Metrics

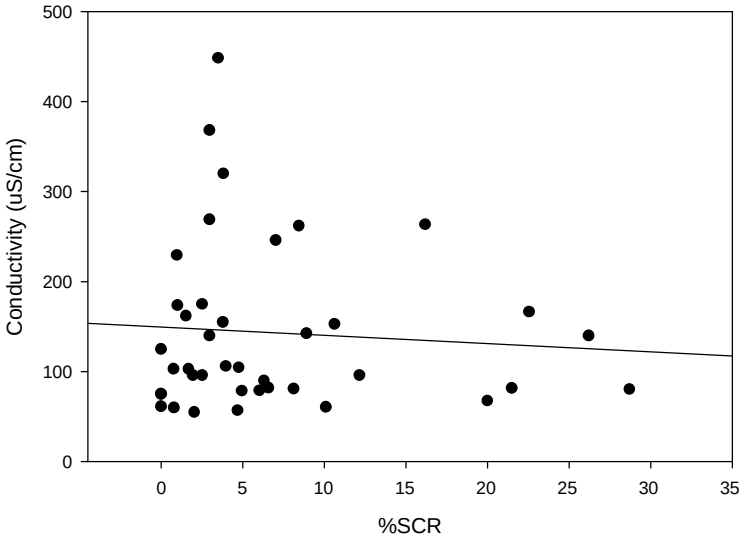
Conductivity vs TAXARICH (r = 0.0330, p= 0.838)



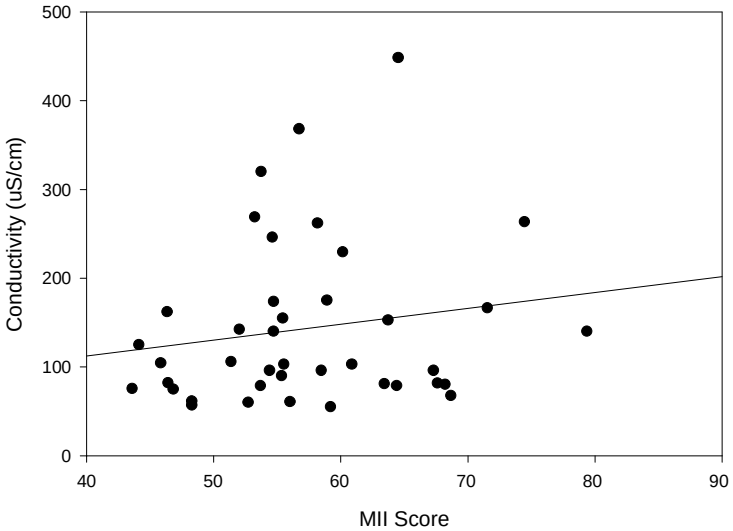
Conductivity vs. PRCNTCOL (r = 0.258, p= 0.108)



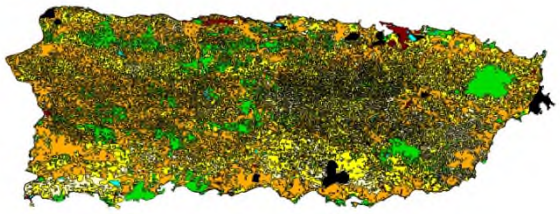
Conductivity vs. PRCNTSCR (r = 0.0536, p= 0.741)



Conductivity vs. MII Score (r = 0.150, p= 0.353)

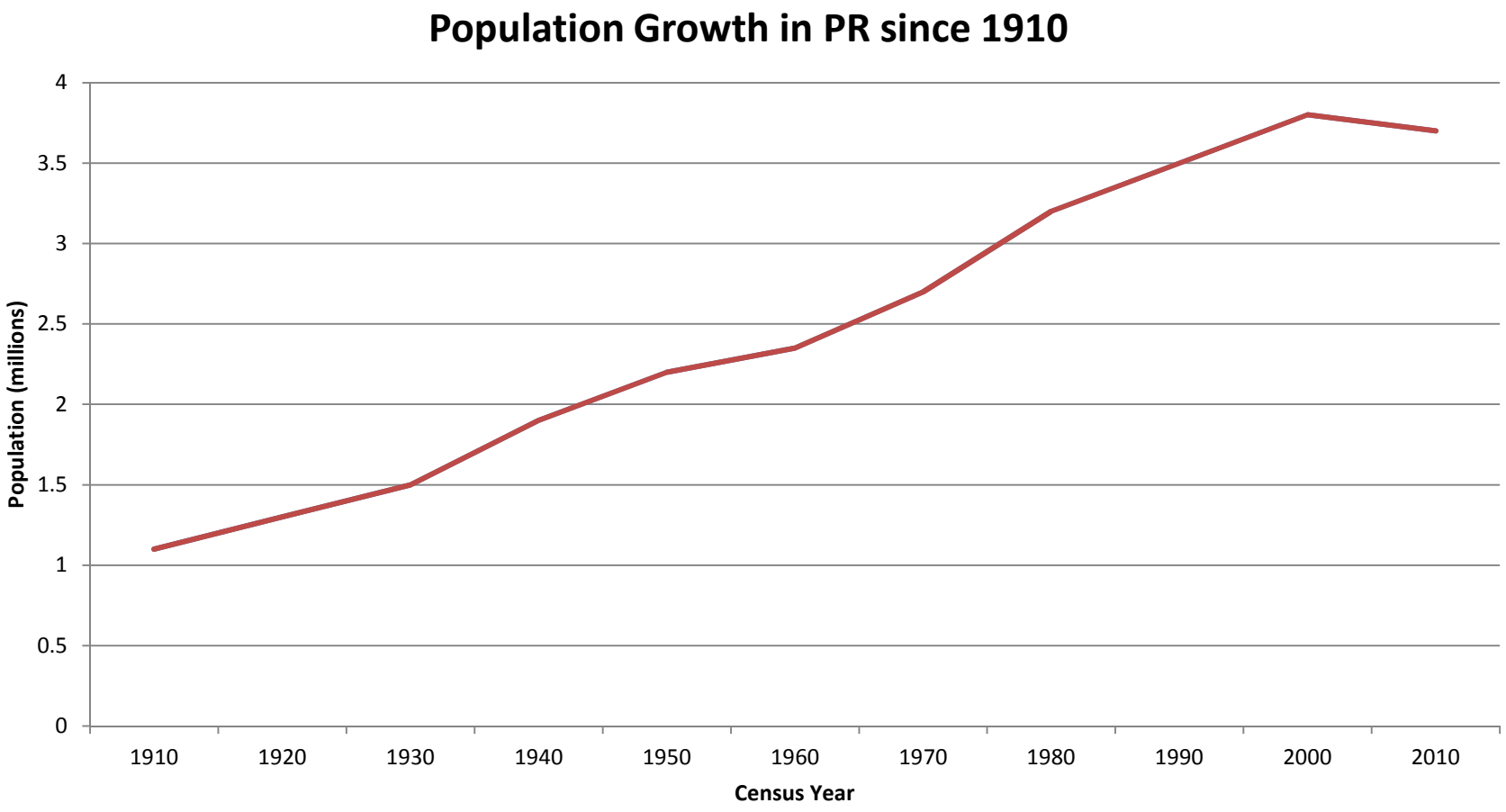


Altered Landscape: The Real Puerto Rico Story

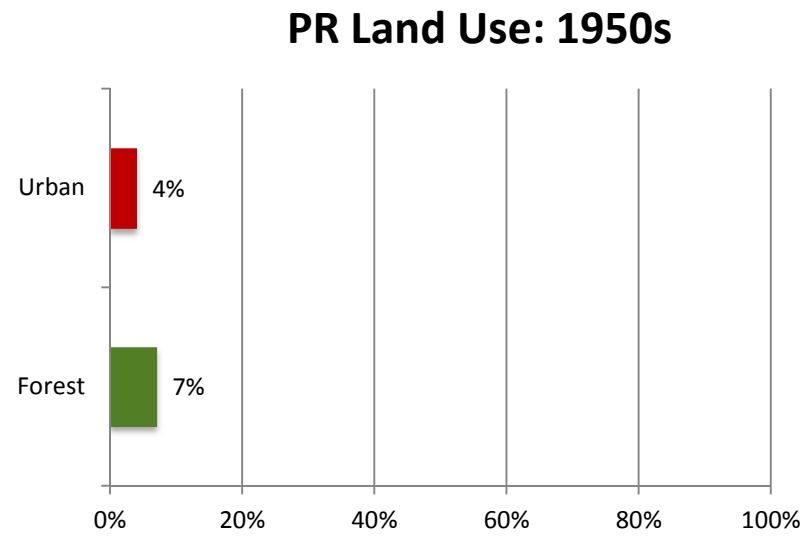


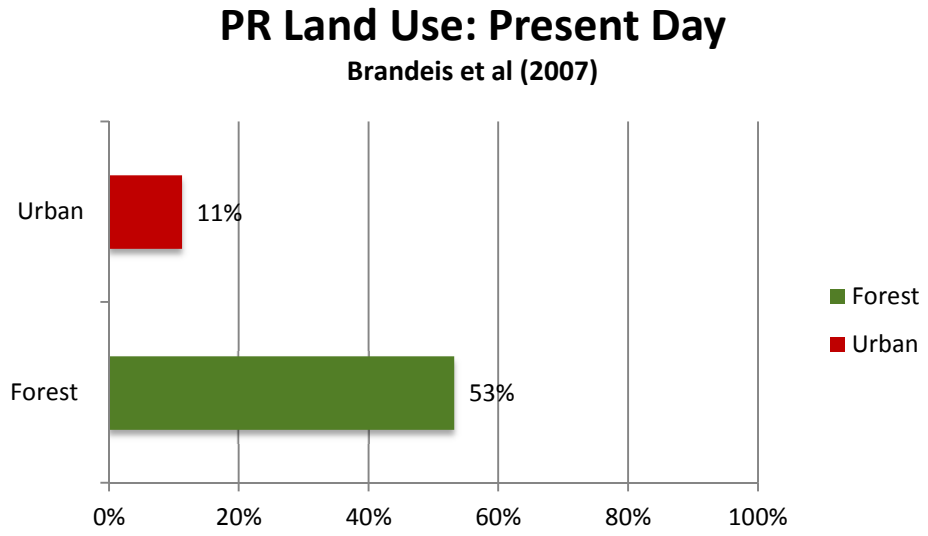
- Rapid human population growth
- Deforestation
- High Dams
- Implications for bioassessment

PR Population Growth



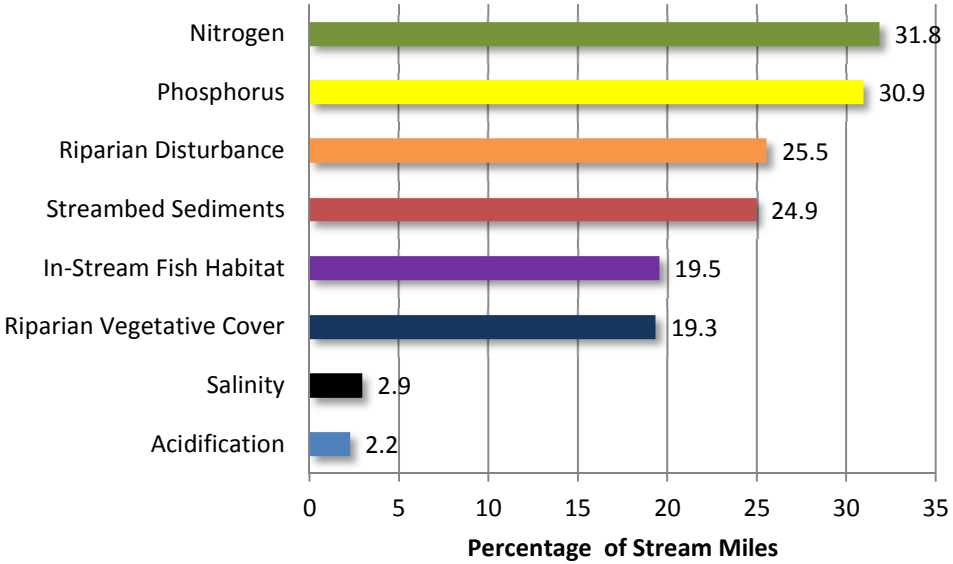
Puerto Rico Land Use



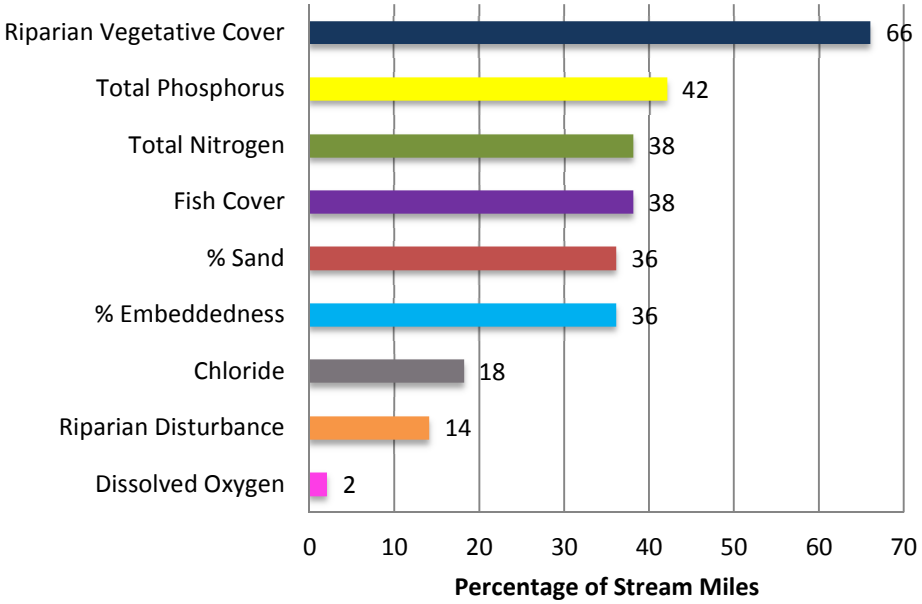


Compare US and PR

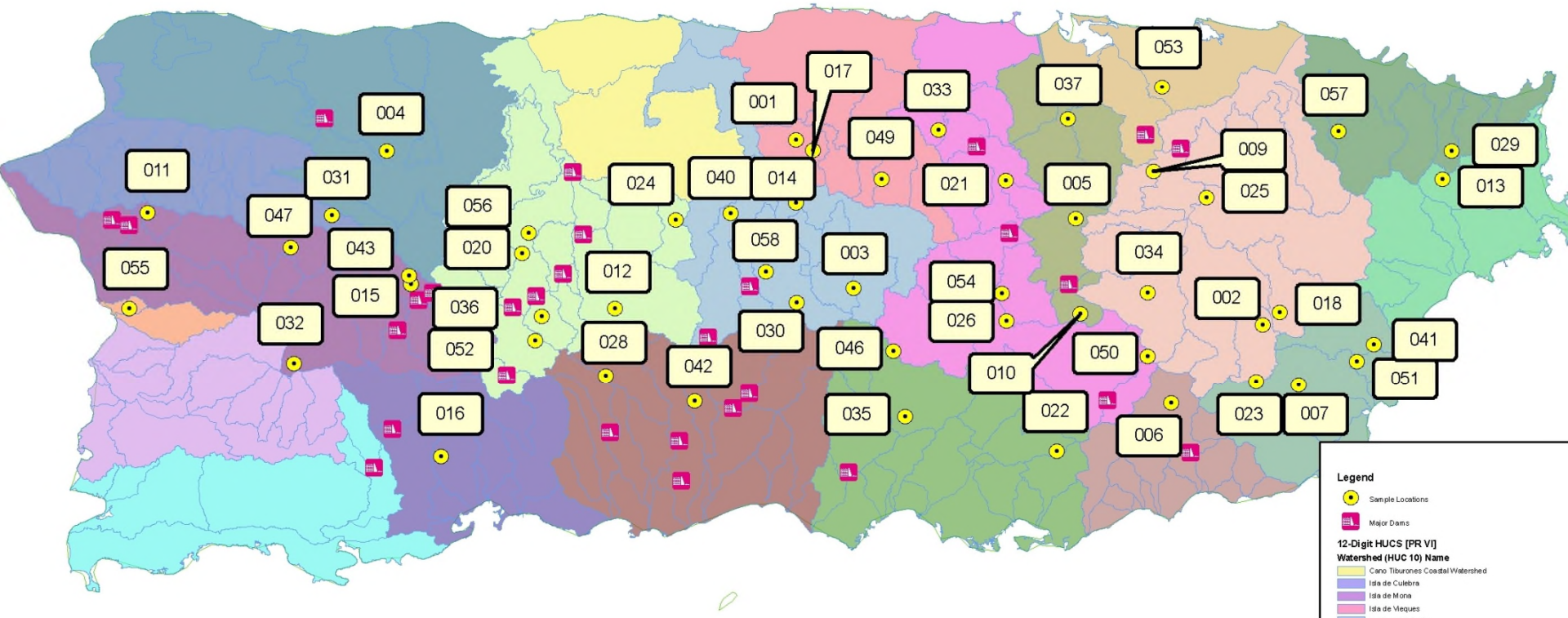
2004 National Streams
Relative Extent in Poor Condition



2009 PR Streams
Stressor Extent in Poor Condition



2009 Puerto Rico Probabilistic Stream Survey



Kilometers
60

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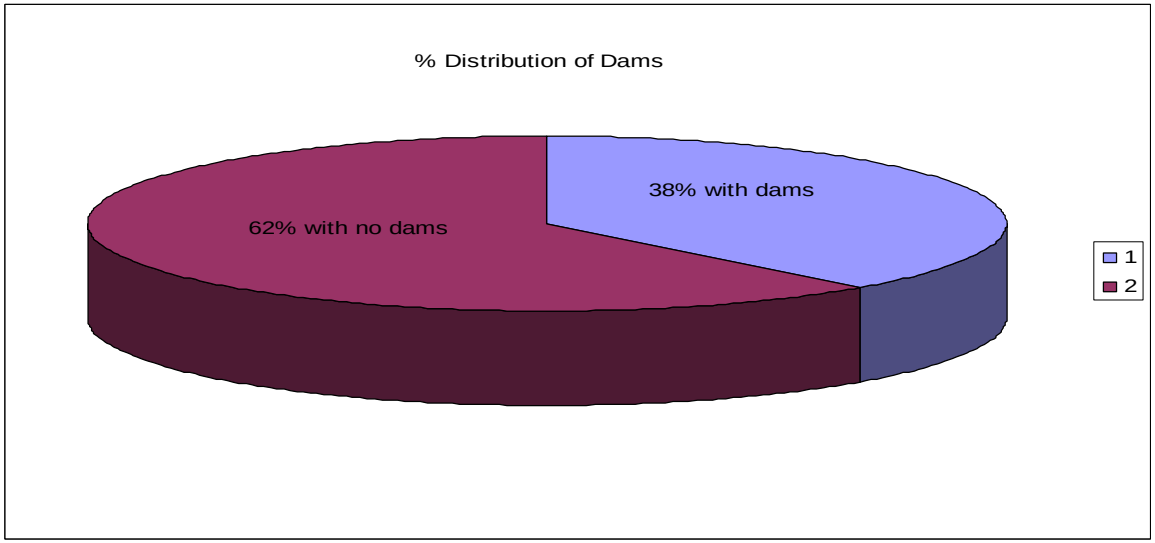
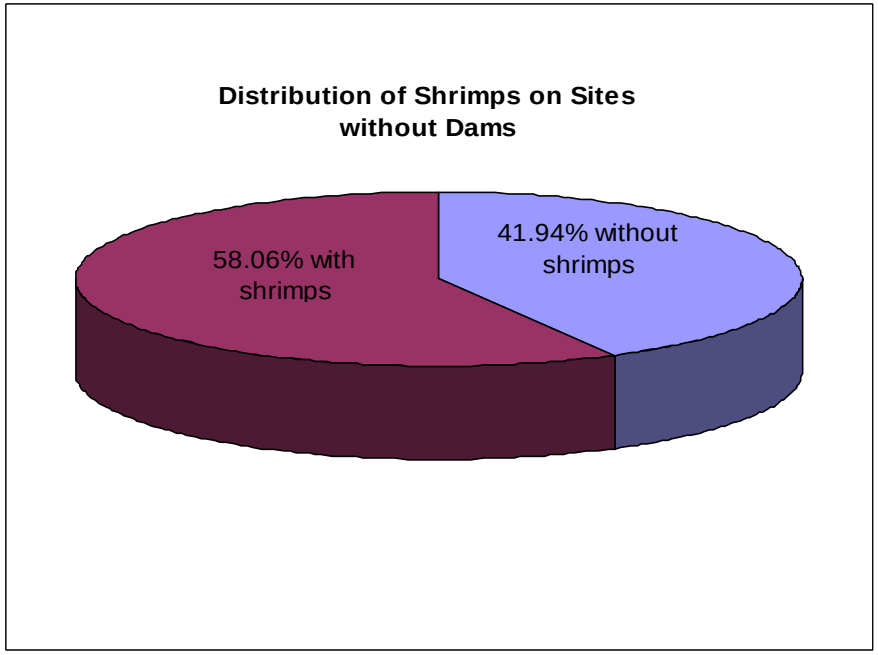
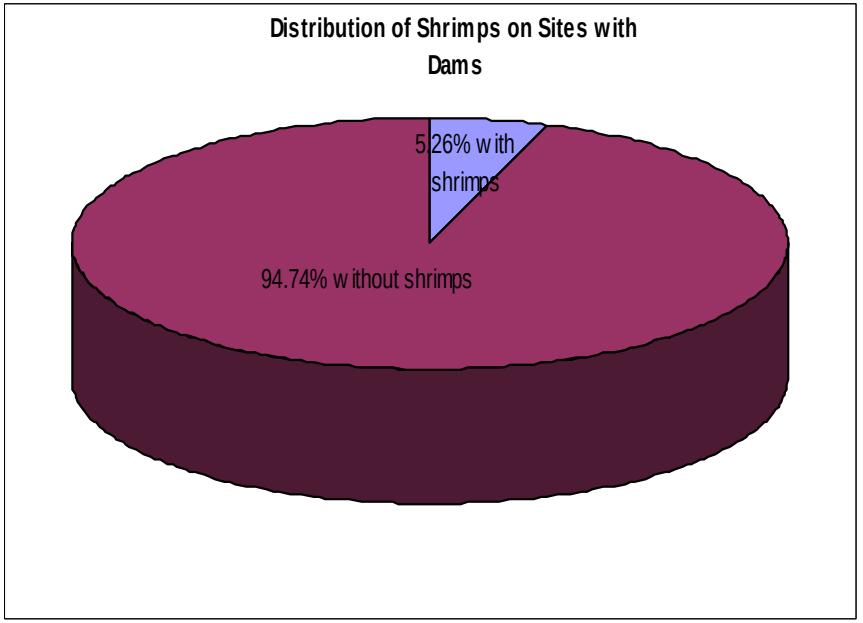
Map Created 1/21/2010

N

Summary on Dams







Condition of Puerto Rico Streams: High Dams

- Caribbean streams are dominated by a native shrimp and fish assemblages that require a marine-upland linkage
- The negative impacts of dams without spillway discharge on native shrimp and fish fauna in Puerto Rico has been documented (Holmquist et al., 1998)
- Our survey confirms the findings of others on the effects of impermeable dams

Reference Stream Findings: Presence/Absence of High Dams

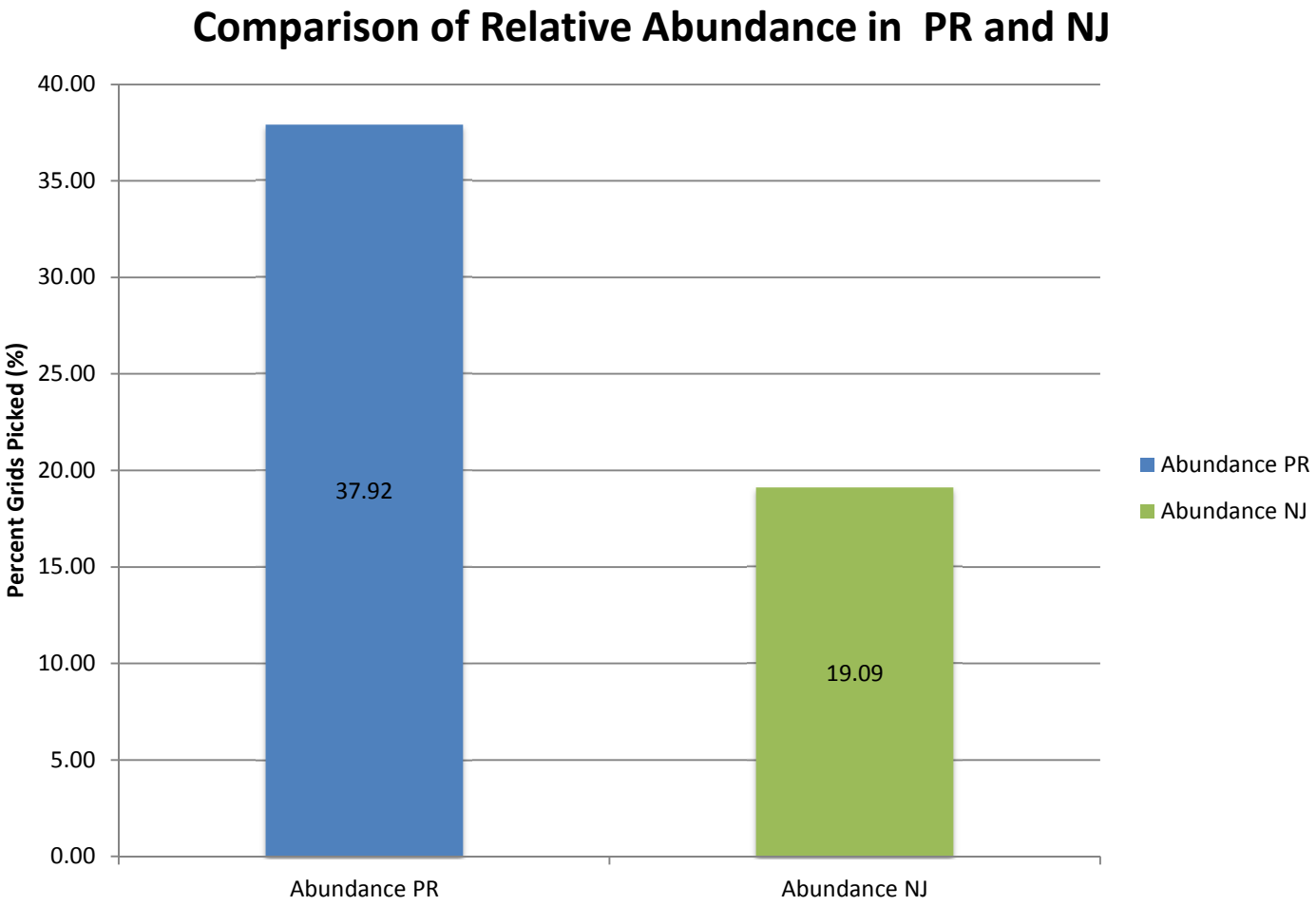
- 42 reference sites (18 w/ dams & 24 w/o dams
- Sites w/o dams had greater crustacean richness and abundance
- Sites w/ dams had higher taxa rich., trichoptera rich., and trichoptera abundance
- Most metric distributions were similar
- MII scores did not vary

Natural Biology and Information Gaps Limit Bioassessment?

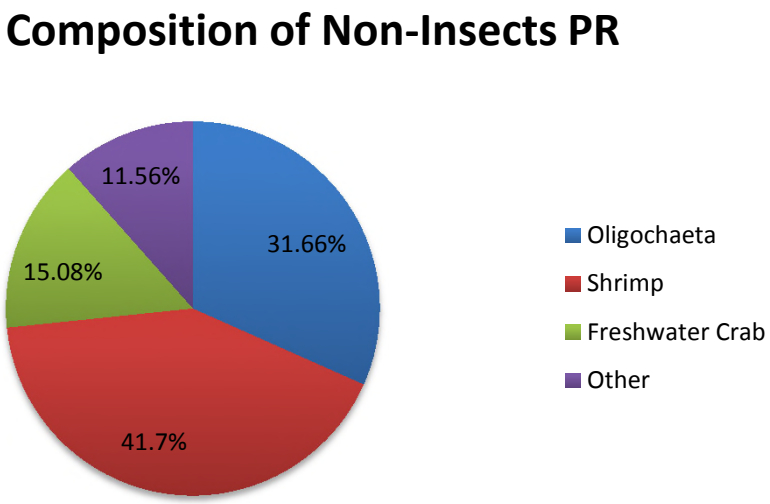
- Taxa richness and abundance
- Invertebrate taxonomy
- Functional Feeding Groups
- Pollution Tolerance Assignments
- Marine-freshwater linkage

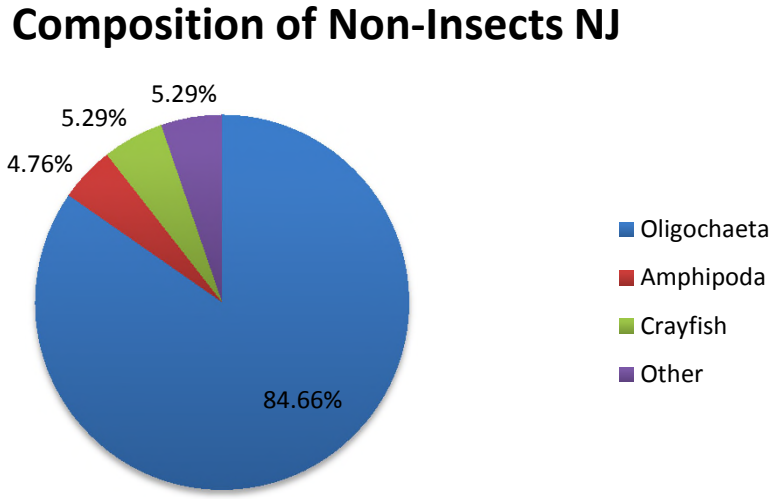
Metric Distributions for $PR_{(n=39)}$ and $NJ_{(n= 26)}$ Reference Streams

Metrics	Similarity
Richness	
Taxa Richness	Dissimilar (> NJ as expected)
Mayfly & Caddisfly Richness	Dissimilar (>NJ as expected)
Caddisfly Richness	Similar
Crustacean Richness	Similar
Percent Composition	
% Caddisfly	Similar
% Caddisfly & Mayfly	Similar
% Lepidoptera	Dissimilar (>PR)
% Mayfly	Dissimilar (>PR)
% Coleoptera	Dissimilar (>PR)
% Diptera	Similar
% Gastropoda	Similar
% Odonata	Similar
% Crustacean	Dissimilar (>PR)
% Chironomid	Dissimilar (>NJ)
% Oligochaeta	Dissimilar (>NJ)
% Non-Insect	Similar (However, composition very different)
Percent Functional Feeding Groups	
% Predator	Similar
% Scraper	Dissimilar (>PR)
% Collector/Filterer	Similar


Comparison of Relative Abundance in PR and NJ
Percent Grids Picked (%)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
37.92
19.09
Abundance PR
Abundance NJ
Abundance PR
Abundance NJ

Non-Insect Composition





Freshwater Macroinvertebrates: PR and NJ

Taxa	Puerto Rico	New Jersey
Ephemeroptera	9 genera, 20 species (Traver, 1938 and Funk, 2001)	35 genera, 55 species
Odonata	25 genera, 44 species (Paulson, 2008)	34 genera, 31 species
Coleoptera	6 genera	53 genera
Diptera-Chironomidae	28 genera (Ferrington et al, 1993)	90 genera
Diptera	35 genera (Flint, 1964; Flint & Masteller, 1993; Masteller & Buzby, 1993) 21 species of Tipulidae (Gelhaus et al, 1993) 6 genera, 11 species of Psychodidae (Wagner & Masteller, 1996)	63 genera
Trichoptera	23 genera, 41 species	54 genera
Lepidoptera	(Limited Information)	6 genera
Hemiptera	(Limited information)	18 genera, 9 species
Oligochaeta	10 genera, 21 species (Wetzel, 2001)	20 genera, 34 species
Crustacea	6 genera (decapoda & amphipoda), 13 species	7 genera (decapoda & amphipoda), 8 species
Gastropoda	14 genera (Holmquist, 2001)	24 genera, 33 species
Totals	Approx: 175 genera, 190 species 49% FFG known, <5% tolerance assignments	Approx: 500 genera 86% FFG known, 90-100% PTV's

Recommendations for Future Bioassessment in Puerto Rico and Caribbean

- Develop field sampling methods and test metrics for streams in the karst and coastal plain regions
- Sample additional reference stream sites and include repeat visits
- Improve invertebrate taxonomy and develop taxonomic keys
- Develop objective pollution tolerance values for invertebrate taxa
- Consider other community components (amphibians, fish, algae)
- Further promote collaborative efforts among freshwater aquatic biologists working in Mesoamerica and Caribbean

Acknowledgements

- Puerto Rico Environmental Quality Board (Robert Ayala, Rafael Cabezudo, Arnaldo Pol)
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